Minuteman III Guidance and Propulsion Replacement Programs

The Minuteman III Intercontinental Ballistic Missile (ICBM) consists of three solid propellant stages (including rocket motors, inter-stage hardware, and ordnance), the liquid Propulsion System Rocket Engine, and the guidance set that can deliver up to three re-entry vehicles. Five hundred Minuteman III ICBMs are currently deployed in hardened launch facilities at three operational bases.

The Guidance Replacement Program (GRP) and PRP are a set of hardware and software modifications designed to extend the service life of the Minuteman III while preserving its current capabilities. This program is needed to prevent a projected decline in reliability due to aging electronic components and unavailable replacement parts. GRP replaces the guidance computer, signal converters, and power distribution components while retaining the current Minuteman III inertial measurement unit. GRP is required to preserve current accuracy and reliability while enhancing supportability.

The Propulsion Replacement Program (PRP) will extend the life of the Minuteman III operational force by replacing the solid propellant propulsion subsystems. Due to observed failure modes (age-related degrades) and the rocket motors' approaching service life, the solid stages now in the force were projected to begin to deteriorate in 2002. PRP will remanufacture the solid rocket motors, inter-stage hardware, and ordnance using new materials and processes that were qualified to replace unavailable or environmentally prohibited materials. In addition to hardware, PRP modifies two Minuteman III software elements: the Minuteman Operational Targeting Program and the Flight Program Constants Tape. These software modifications require use of the GRP-modified guidance system.

DOT&E conducted an independent assessment of the GRP program from 1996 through 1999, culminating in submission of a report to Congress in December 1999 in fulfillment of the provisions of Title 10, U.S. Code, Section 2399. DOT&E determined that the GRP upgrades were operationally effective and suitable, although there had been insufficient numbers of flight tests (two) to confirm the accuracy and reliability assessments. The Air Force proceeded to full-rate production of the modified guidance systems in December 1999.

After two GRP flight tests and two PRP flight tests, the accuracy evaluation was still subject to considerable uncertainty. DOT&E required three additional flight tests to give the evaluation higher confidence in the demonstrated performance results. DOT&E agreed to accept data from already scheduled Minuteman III Force Development Evaluation (FDE) program flight tests as long as the missiles were configured with the GRP modified guidance system. These flights were conducted in FY01. DOT&E completed its independent assessment of the PRP program, culminating in submission of a report to Congress in September 2001 in fulfillment of the provisions of Title 10, U.S. Code, Section 2399. The Air Force approved full-rate production in September 2001.

The Guidance Replacement Program and the Propulsion Replacement Program are a set of hardware and software modifications designed to extend the service life of the Minuteman III while preserving its current capabilities.

TEST & EVALUATION ACTIVITY

All programmed operational test activities have been completed for GRP and PRP. Both programs are currently in full-rate production.

TEST & EVALUATION ASSESSMENT

DOT&E found both GRP and PRP to be operationally effective and suitable even though accuracy performance, which is primarily attributed to the guidance system modified by GRP, fell slightly short of the operational requirement. DOT&E determined that the shortfall in accuracy is offset by the overall improvement in weapon system reliability, which makes the Minuteman III weapon system more operationally effective than Minuteman III with the current guidance and propulsion systems.

After seven flight tests with the modified guidance system, the Air Force found that accuracy results were not in agreement with expectations. Accordingly, the Air Force conducted a supplemental accuracy investigation under the guidance of a Senior Review Team (SRT). The SRT assessment identified two primary sources of bias error in the guidance system software. One source was erroneous implementation of computational precision. In some navigation calculations, truncation was implemented where round-off was intended. In some guidance calculations, better approximations were needed to maintain adequate precision.

The other primary error source was a small, undesired residual velocity bias introduced into the calculations that govern the attitude of the re-entry vehicles at deployment. The factors leading to the bias have a complex dependence on the azimuth and trajectory. For test-flight missions from Vandenberg Air Force Base to Kwajalein, the errors reinforce one another. In other trajectories, the errors might increase dispersion but not contribute significantly to the weapon delivery error. Operational trajectories would still have been less than optimum if this situation had not been discovered, so it is fortunate that the westerly test trajectory highlighted the problem. Since the government may not want to rely on chance discovery in the future, it is worth noting that most anomalies can be detected if sample size is adequate. The SRT recommended expanding the rate of Minuteman III FDE flights from three to five per year, for at least five years.

The Air Force initiated corrective actions though an Accuracy Upgrade Program (AUP). The first flight of the Minuteman III with the corrections incorporated into the NS-50 guidance set occurred on June 7, 2002. Initial impressions of the results were very positive. The downrange biases observed previous to the AUP modifications appeared to have been corrected. DOT&E will continue to monitor this situation.